SOLVENT CONTAMINATED WIPERS
DATA COLLECTION EFFORT

EVALUATION OF THE SOLVENT EXTRACTION EFFICIENCY OF AN INDUSTRIAL CENTRIFUGE ON A VARIETY OF SHOP TOWELS AND WIPERS

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FINAL REPORT

1.0 Introduction:

This Quick Response Task (QRT) report is part of the continued the data collection efforts initiated under Contract No. 68-W4-0042. The QRT continues a data-generating effort to support the Agency's evaluation policy for solvent-contaminated shop towels and wipers, i.e., whether to maintain current policy or modify existing policy to improve industry compliance. This report details the equipment and procedures used to evaluate and characterize the solvent extraction efficiency of an industrial centrifuge on a variety of industrial towel and wiper/solvent combination. For the purpose of this report, the term "shop towel" refers to reusable products and the term "wiper" refers to disposable products.

The procedure used to perform the evaluation involved pre-weighing a known number of five different shop towels and wipers. An amount of solvent equivalent to a predetermined proportion of towel/wiper weight was then weighed-out and added to the towels/wipers. Metal paint pails with covers were used to store the towels/wipers during the weighing and to transport the towels/wipers to the centrifuge. Each type of towel or wiper was placed in a separate mesh laundry bag and placed in the centrifuge. Some clean towels were added to the centrifuge as ballast to help simulate a full run. The centrifuge was run for five minutes, the towels/wipers were removed, and each type of towel/wiper was reweighed. The known weight of the towels/wipers before the addition of the solvent, the weight of the solvent added, and the final weight of towel/wiper were used to calculate the amount of solvent left on the towels/wipers after centrifugation and the extraction efficiency of the centrifuge. The centrifuge used in the evaluation is currently used to extract solvents from launderable towels at a large printing facility. This technology is considered a high-end solvent extraction technology.

2.0 Equipment and Supplies:

2.1 Centrifuge:

- Bock Engineered Products, Inc. (Model SP655) fixed speed (1600 rpm), self balancing, explosion proof, manually controlled centrifuge. The centrifuge could handle 60 lbs (dry weight) and has a stainless steel basket that is 24" wide and 16" deep.

2.2 Solvents:

- MEK (methyl ethyl ketone), CAS# 78-93-3, technical grade
- IPA (isopropyl alcohol), CAS# 67-63-0, technical grade
- VM&P Naphtha (light aliphatic petroleum naphtha solvent), CAS# 64742-89-8, technical grade
- 1044 Press Wash (from Worum Chemical Co., St. Paul, MN), a solvent mixture made for The John Roberts Co. which includes: Worum DPM, Rule 66 Mineral Spirits (aliphatic C8-C11 hydrocarbons), Aromatic 100 (aromatic C8-C12 hydrocarbons), Surfonic N-40, and Surfonic N-95.
- Used 1044 Press Wash extracted from dirty towels using the centrifuge at The John Roberts Co., contains 1044 Press Wash solvent along with ink, dirt, oil, and/or water.

2.3 Towels/Wipers:

- Launderable towels: roughly 12" x 12" cotton towels, provided commercially by industrial laundries
- Disposable cloth wipers: various pieces of used or discarded clothing cut into roughly 8" x 8" squares and sorted into 5 types - light knit (i.e., t-shirts), heavy knit (i.e., sweatshirts), flannel, linen (i.e., sheets, tablecloths, or napkins), and towel (i.e., heavy looped cotton).
- Disposable wipers:

  Kimberly-Clark Workhorse manufactured rags - 13.2" x 13.5"
  Kimberly-Clark Kimtex Shop Towels - 12" x 14"
  DuPont SontaraEC engineered-cloth wipers - 9" x 16.5"

2.4 Balances:

- a top loading balance, capable of measuring to the nearest ± 0.1 g with a maximum capacity of 250 g. Used to measure towel/wiper weights below 250 g.
- a top loading balance, capable of measuring to the nearest ± 5g with a maximum capacity of 2500 g. Used to measure solvent weights and towel/wiper weights above 250 g.

2.5 Safety Equipment:

- safety glasses
- solvent resistant gloves
- clean metal paint pails (about 1.5 gallon) with lids for transporting towels/wipers

2.6 Additional Equipment:

- a 4 cup and a 2 cup Pyrex glass measuring cups used to measure out solvent for weighing
- lightweight aluminum foil pans used to contain solvent-soaked towels/wipers for weighing
- stopwatch capable of countdown from 5 minutes
- thermometer for measuring room temperature
- mesh laundry bags 11" x 14"
- Pressman solvent pump can

3.0 Test Facility/Equipment:

To begin this experiment, a facility was chosen where solvents were removed from used shop towels with an industrial centrifuge. The John Roberts Co. in Coon Rapids, MN was selected for the project because they had been using this technology for several years. The facility had purchased their centrifuge in 1989 for about $13,410, not including installation and VOC control costs. Once installed, the centrifuge was tested to determine the optimum extraction time for the towels and solvents used at the facility. Once the system was optimized, the centrifuge has been used to extract solvent from launderable towels for several hours a day in about 5 minute intervals without any major problems. According to the facility Environmental Director, the only major yearly maintenance cost has been the once-a-year purchase of a $17 rim gasket, the labor to install the gasket, and the periodic labor to clean-out the build-up of ink and dirt from the center of the stainless steel basket. The situation at The John Roberts Co. represented to the experimenters the long-term successful use of centrifuge extraction technology.

4.0 Test Solvents:

4.1 The solvents used for the experiment were chosen for several reasons. MEK, IPA, and VM&P Naphtha were selected as solvents because of their use by industry and because they represented three different organic solvent types: ketones, alcohols, and petroleum hydrocarbons. These solvents had also been tested in previous extraction technology evaluations. Acetone was discussed as an additional solvent for testing but was rejected because another ketone, MEK, was already being tested. Methylene chloride was also discussed as a testing solvent but was rejected because of its relatively high toxicity and new EPA regulations strongly discouraging use of the solvent in the workplace.

4.2 In addition to previously tested solvents, a solvent blend used at the facility was tested. Use of low volatility solvent blends is common in the printing industry. The blend tested was unique and made just for the facility. For comparison purposes, the dirty extracted solvent from the centrifuge was also tested. The dirty solvent was dark blue in color from co-extracted ink in the centrifugation process. The Environmental Director of the facility indicated that some dirt, water, and oil were also likely to be present in the extracted solvent. The dirty solvent was tested on the towels and wipers in an effort to better simulate the extraction of the complex mixture of solvent, ink, oil, dirt, and water that might be found on actual towels or wipers. The dirty solvent was poured on the towels and wipers to be tested in the same fashion as the clean solvents. The amount of each solvent used in testing was weighed-out on a balance.

4.3 The amount of solvent that was added to the towels and wipers was discussed prior to the experiment. A solvent to towel or wiper ratio of 2x (i.e., the weight of solvent added to the towel or wiper equal to twice the weight of the towel or wiper) was agreed upon for the first part of the experiment. Under previous work assignments, solvent ratios of 0.5x and 2x were employed to compare the removal efficiencies of extraction technologies. A 2x ratio was also used in the previous screen-bottom drum experiments. Therefore, for the purpose of data comparability, a 2x solvent to towel/wiper ratio was used in the investigation. An additional experiment at 0.5x solvent to towel/wiper ratio was also run (using only the 1044 Press Wash) to determine extraction efficiency was different at that ratio. In addition, while performing the experiment, it was suggested by the Environmental Director of the facility that the towels/wipers be tested at saturation. He suggested this approach since the pressmen at his facility often used a saturated towel to wipe off the presses. Based on this suggestion, an additional test was run using towels and wipers saturated with 1044 Press Wash.

4.4 The original plan for this experiment had included 2 additional tests. The personnel running the experiment had planned to vary the load size to 25% of a normal load. This test was abandoned when the amount of clean ballast towels used in the centrifuge was determined to be only 1.66 kg (or 2.6 lbs). The impact of decreasing the ballast load by about 1.2 kg was thought to be insignificant considering the centrifuge could handle a maximum dry weight of 60 lbs. In addition, the experimenters had planned to run the centrifuge for 2.5 minutes and for 7.5 minutes to see if there was any difference in performance. However, once the centrifuge was used, it became very obvious that when the centrifuge had completed extracting all the solvent it could, the stream of solvent pouring into the solvent collection pail stopped. When the stream of solvent ended, the

centrifuge could be turned off. In all tests, the stream had stopped or was down to a tiny trickle by the time 5 minutes had passed. The personnel running the experiment determined that there was no need to gather data on the impact of spin time since it was easy to observe when the centrifuge had completed the job.

5.0 Towels/Wipers:

The towels and wipers selected for the experiment (Section 2.3) were based on earlier studies of what industry actually uses and what had been previously tested.

5.1 Launderable towels were selected as a test material for the experiment. Since the weight of the launderable towels was more variable, 20 towels were tested in each run. Due to the larger number towels run, no mesh laundry bag was used to separate the launderable towels. The towels were simply placed in the centrifuge along the outer basket edge and away from other towels or wipers being tested.

5.2 Disposable cloth wipers presented a problem for testing since used clothes come in various fabrics and sizes. To address this problem, the used clothing provided by ERC Wiping through SMART was sorted into 5 groups (see the equipment section above). Some types of clothing, like denim and corduroy, had to be completely ignored because not enough of that type of used cloth was supplied. The sorted cloth was then cut into roughly 8" x 8" squares for testing consistency. Two of each of the 5 cloth types were tested in each centrifuge run and each piece was individually weighed (a total of 10) because of concern about the limited number of towels available for testing. To mark the two pieces of cloth from one another, a large cut was made with a scissors on one of the towels. Disposable cloth wipers were tested together in a mesh laundry bag since they would likely be used in that fashion.

5.3 Disposable paper wipers are commonly used by industry were tested in this experiment. Two previously tested wipers from Kimberly-Clark were tested: Workhorse and Kimtex. Additionally, a wiper from DuPont called SontaraEC was also tested. DuPont originally sent two types of wipers for testing. However, the only difference between the two wiper types was the color: white and blue. DuPont agreed that simply testing the white wiper would suffice. Kimberly-Clark Kimwipes were also discussed as a possible testing wiper but were rejected since they are only used for light industrial work. Earlier studies indicate that they do not hold much solvent before free liquids are released. Since the weight of the disposable wipers was relatively consistent, only ten wipers of each type were tested in each run. Each disposable wipers type was tested in its own mesh laundry bag.

6.0 Procedure:

6.1 Individual Solvent Tests:

Initial experiments were performed by loading the five towel/wiper types with one of the five solvent types. To begin this process, 10 wipers of each disposable wiper type were weighed and the

average weight was determined. This average weight was used throughout the experiment because the wipers were so uniform in size and shape. Next, 20 launderable towels were weighed out and an average weight was determined. The average weight was determined for each centrifuge run since the towel weights were more inconsistent. Finally, 10 disposable cloth wipers were weighed and the weight of each towel was recorded. As previously mentioned, 2 of each different cloth type were tested giving a total of 10 towels. A scissors was used to cut a mark in every other towel so that after the centrifuge run each towel could be identified again.

TABLE 1 NUMBER OF TOWELS/WIPERS TESTED IN EACH RUN	
10	Workhorse
10	Kimtex
10	SontaraEC
10	Disposable cloth wipers (2 of each cloth type)
20	Launderable towels (no mesh laundry bag used)

The towels and wipers were loaded by weighing out an amount of solvent equal to 2 times the total weight of the towels/wipers. In past studies, a volume of solvent was added that was adjusted for density. However, a scale capable of weighing out larger amounts of solvent was available at the facility so solvents were measured out based on weight rather than volume. An average towel or wiper weight was used to determine the amount of solvent to be added to the launderable towels and disposable wipers. The actual weight of the disposable cloth wipers was used to determine the weight of solvent added since the disposable cloth wiper weights varied significantly.

TABLE 2 SOLVENTS TESTED (1 solvent type per run)
MEK or Methyl ethyl ketone
IPA or isopropyl alcohol
VM&P Naphtha
1044 Press Wash
Used 1044 Press Wash

Once the solvent was measured, it was added to each towel/wiper by placing an amount of the measured solvent on each towel or wiper. If any solvent was left after adding the solvent to each towel/wiper, it was poured over the edge of the stack of towels/wipers in an effort to expose each towel/wiper in the stack to some of the solvent. This approach was assumed to be reasonable since the solvent in the towel would be pulled by the pinning centrifuge through the other towels. The

stack of solvent soaked towels/wipers was then immediately placed in a mesh laundry bag and the bag was placed in a covered metal pail for transport to the centrifuge. Due to the larger number of launderable towels run and the relative size of the mesh laundry bag, no mesh laundry bag was used to hold the launderable towels.

After being transported to the centrifuge, the towels/wipers in their mesh laundry bags were then placed in the centrifuge and distributed inside the basket so that there was no overlap or touching of a towel or wiper type with the next type. Next, some clean launderable shop towels, supplied by facility, were added to the centrifuge as ballast. The weight of the ballast towels were 1.66 kg. Beginning at the start of a stop watch, the centrifuge operator started the centrifuge and let it run for exactly 5 minutes. At the completion of the run, the centrifuge was allowed to stop spinning and the towels and wipers were removed from the centrifuge and immediately placed in covered metal pails for transport back to the facility weighing room.

In the weighing room, each wiper and towel was weighed and results were recorded on a data sheet. To save weighing time, only 10 of the launderable towels were weighed even though 20 towels were run in the centrifuge. Each of the disposable cloth wipers were weighed and matched up to their original weight using the markings given to them earlier. Finally, after the weighing was complete, the towels and wipers were placed into the hazardous waste container. This procedure was completed 5 times for each solvent using the 5 different towels and wiper types in each run.

6.2 Additional Blended Solvent Tests:

In the second part of the experiment, two additional tests were run with the 1044 Press Wash using all 5 different towel/wiper types. For these additional tests, different amounts of solvent were added to the towels/wipers.

In the first test, the entire stack of each towel or wiper type was weighed as a group, except for the disposable cloth wipers. The disposable cloth wipers were weighed individually and marked for identification later. The towels/wipers were then taken to a pressman's solvent pump can. Instead of adding a known amount of solvent to the towels/wipers, the towels/wipers were submersed in the solvent pump can 2 at a time until they were dripping. The experimenter then lifted the dripping towels/wipers and gently squeezed the towels/wipers until no more solvent dripped. He then placed the towels/wipers in metal paint pails with covers for transport to the weighing room.

In the weighing room, the each stack of towels or wipers was weighed again (except for the disposable cloth wipers) to determine the total weight of solvent added to the towels/wipers. The disposable cloth wipers were weighed individually. The solvent soaked towels and wipers were taken to the centrifuge in metal paint pails, run for 5 minutes, and returned to the weighing room for another measurement. Again, each stack of towels or wipers was weighed (except for the disposable cloth wipers) to determine the total weight of solvent remaining on the towels/wipers. The disposable cloth wipers were weighed individually. Results were recorded on a data sheet.

In the second test, the entire stack of each towel or wiper type was weighed as a group, except for the disposable cloth wipers. The disposable cloth wipers were weighed individually and marked for identification later. The towels/wipers were then loaded with 0.5 times the weight of the towel or wiper being tested using the same technique as was used in Part 1 of the experiment (the solvent was weighed). The towels and wipers loaded with 0.5x of solvent were taken to the centrifuge in metal paint pails, run for 5 minutes, and returned to the weighing room for another measurement. Again, each stack of towels or wipers was weighed (except for the disposable cloth wipers) to determine the total weight of solvent remaining on the towels/wipers. The disposable cloth wipers were weighed individually. Results were recorded on a data sheet.

7.0 Calculations:

7.1 For the 2x solvent loaded launderable towels and wipers (T), the average solvent extraction efficiency (%) was calculated as follows:

Eq.1 [1 - [(ave. final T wt.) - (ave. T wt.)]/[2 x (ave. T wt.)]] x 100

For the solvent saturated launderable towels and wipers (T), the average solvent extraction efficiency (%) was calculated as follows:

Eq.2 [1 - [(total final T wt.) - (total T wt.)]/[(total saturated T wt.) - (total T wt.)]] x 100

For the 0.5x solvent loaded launderable towels and wipers (T), the average solvent extraction efficiency (%) was calculated as follows:

Eq.3 [1 - [(total final T wt.) - (total T wt.)]/ [0.5 x (total T wt.)]] x 100

7.2 For the 2x and 0.5x solvent loaded disposable cloth wipers (DCW), calculate the solvent extraction efficiency (%) for each wiper was calculated using the following equation:

Eq.4 [1 - [(final DCW wt.) - (initial DCW wt.)]/[2 x (initial DCW wt.)]] x 100

Then, the average solvent extraction efficiency (%) for the disposable cloth wipers (DCW) was calculated as follows:

Eq.5 [(ave. solvent extraction eff. of DCW1) + (ave. solvent extraction eff. of DCW2)] ÷ 2

For the solvent saturated disposable cloth wipers (DCW), the average solvent extraction efficiency (%) was calculated as follows:

Eq.6 [1 - [(final DCW wt.) - (initial DCW wt.)]/[(solvent soaked DCW wt.) - (initial DCW wt.)]] x 100

The average solvent extraction efficiency (%) for the disposable cloth wipers (DCW) was calculated as in Equation 5, above.

8.0 Results:

From these experiments, the extraction efficiency of the centrifuge was calculated using the equations in Section 7.0. A summary of all the results from this experiment can be found in Table 4. To properly present the data in Table 4, the data were broken out into two groups: one group where 10 towels or wipers were measured and a second group of disposable cloth wipers where only 2 towels were measured. Calculation of standard deviation was viable for the towel/wipes types containing 10 measurements and are presented in the table

The solvent that seemed to be most easily extracted was MEK. The fact that MEK had the highest average extraction efficiency (99% for all towel/wiper types) is not surprising considering it has the highest vapor pressure and lowest boiling point (see Table 4). The solvent that had the lowest average extraction efficiency (90% and 88% for all towel/wiper types) for the 2x solvent load was the Used 1044 Press Wash. This is also not surprising considering that the Used 1044 Press Wash contained ink, water, dirt, and/or oil from the presses that was likely more difficult to extract from the towels. It should be noted that all of the towels turned a noticeable blue color after the addition of the Used 1044 Press Wash solvent.

The average extraction efficiency of the saturated 1044 solvent run was higher than that calculated for the 2x 1044 solvent run (94% and 95% for the saturated run compared to 91% and 94% for the 2x run). This performance seems appropriate when one considers that more solvent was added to the saturated towels/wipers but approximately the same amount of solvent remained on the towels/wipers after the centrifuge run (see Table 3).

TABLE 3
AVERAGE FINAL 1044 PRESS WASH SOLVENT LOAD WEIGHT (g)

Solvent to Towel/Wiper Ratio	0.5x	2x	Saturated
Launderable towels	1.8	2.4	2.3
SontaraEC	0.8	1.0	1.0
Kimtex	1.0	1.9	1.8
Workhorse	1.8	2.4	2.3
Disposable cloth wipers (2 of 5 cloth types)	1.3	1.5	1.3

The relatively poor performance of the 0.5x 1044 solvent run (about 75-76%) can also be explained by looking at the amount of solvent left on the towels/wipers after the run in Table 3. In the 0.5x run, only a quarter of the amount of solvent was added to the towels/wipers, compared to the 2x run. However, the amount of solvent left in the towels/wipers after the 0.5x centrifuge run was more than half of the amount of solvent remaining after the 2x run or the saturated solvent run. The limited results of these data indicate that extraction efficiency is directly proportional to solvent load. The Table 3 results seem to indicate that some minimal amount of solvent remains in the towel/wiper after centrifugation.

TABLE 4
SOLVENT EXTRACTION EFFICIENCY BY CENTRIFUGATION

AVERAGE SOLVENT EXTRACTION EFFICIENCY (%)									
Solvent to Towel/Wiper Ratio ➤	-	2x	2x	2x	2x	2x	0.5x	Saturated	
Towel/Wipers Tested	# Items Measured[3]	IPA	MEK	VM&P Naphtha	Used 1044 Press Wash	1044 Press Wash	1044 Press Wash	1044 Press Wash	**Avg. Ext. Eff. (%)**
Launderable Towels	10[1]	96	100	96	94	95	82	95	**94**
SontaraEC Wiper	10	94	99	99	93	93	79	95	**93**
Kimtex Wiper	10	92	99	91	87	87	73	93	**89**
Workhorse Wiper	10	89	96	93	86	89	66	91	**87**
Avg. Extraction Efficiency (%)	-	**93**	**99**	**95**	**90**	**91**	**75**	**94**	**Midpoint Avg. Ext. Eff. (%)**
Standard Deviation of Average	-	**3**	**1.7**	**3.5**	**4.1**	**3.7**	**7.1**	**1.9**	
Linen[2]	2	97	101	99	91	94	73	94	**93**
Towel[2]	2	97	97	95	91	95	77	95	**92**
Light Knit[2]	2	98	99	96	84	92	73	92	**91**
Heavy Knit[2]	2	95	100	96	85	94	89	97	**94**
Flannel[2]	2	92	99	98	91	93	68	96	**91**
Average Midpoint Extraction Efficiency (%)	-	**96**	**99**	**97**	**88**	**94**	**76**	**95**	
Vapor Pressure in mmHg	-	32 @ 68°F	70.9 @ 68°F	15 @ 70°F	Unknown	2.9 @ 68°F	2.9 @ 68°F	2.9 @ 68°F	

AVERAGE SOLVENT EXTRACTION EFFICIENCY (%)									
Solvent to Towel/Wiper Ratio ➤	-	2x	2x	2x	2x	2x	0.5x	Saturated	
Towel/Wipers Tested	# Items Measured[3]	IPA	MEK	VM&P Naphtha	Used 1044 Press Wash	1044 Press Wash	1044 Press Wash	1044 Press Wash	**Avg. Ext. Eff. (%)**
Boiling Point at 1 atm	-	180°F	175°F	235-284°F	Unknown	305°F	305°F	305°F	

Spin Time: 5 min. Temperature in Measuring Room: 77°F

[1] 20 towels were run in centrifuge, but only 10 towels measured.

[2] Disposable cloth wipers from used clothing cut into 8" x 8" squares.

[3] Number of towels or wipers measured in centrifuge run.

The difference in the performance of the various towels and wipers was not very dramatic. The launderable towels and the disposable heavy knit cloth wipers performed the best with an average extraction efficiency of 94%. The other wiper and towel types had a performance very similar, but slightly less efficient than the top two performers (See Table 4). The worst performer was Workhorse wiper which still had a respectable 87% average extraction efficiency.

The results from centrifuge extractions done in these experiments were quite good when compared to other extraction technologies from previous work assignments (See Table 5). The only technology that surpassed the performance of centrifuge extraction done in this experiment was air drying. However, the technology for recapturing a high volume of solvent from a towel or wiper after air drying has not been developed.

TABLE 5
COMPARISON OF VARIOUS SOLVENT REMOVAL TECHNOLOGIES[1]

Technology	Removal Efficiency Range
High-volume Air Drying	Near 100%
Centrifugation (from this experiment)	66% - 100%
Mechanical Wringing	1.5% - 68%
Screen Bottom Drums	4% - 28%

[1] Results from previous studies done in EPA Work Assignments.

9.0 SUMMARY AND RECOMMENDATIONS:

This experiment tested the solvent extraction efficiency of one centrifuge on five different towel/wiper types and 5 different solvent types. As summarized in Tables 4 and 5, the solvent extraction efficiency of the centrifuge studied in this experiment was very good (88%-99%), relative to other technologies previously evaluated, and seems to have potential as a long term solution to the removal of solvent from towels and wipers prior to disposal or laundering. Further, the technology easily captures the used solvent for reuse or recycling.

Several issues were not addressed in the experiment and may need to be evaluated. One potential issue is that towels/wipers with high amounts of water and solvent were not evaluated. In the printing industry, use of water/solvent mixtures for washing presses exists in the marketplace and the experiment performed for this study did not address water:solvent ratios closer to 1:1. In addition, these experiments could be extended to other faster centrifuges with larger capacities for larger facilities with greater towel/wiper use, such as large metropolitan newspapers, or smaller more inexpensive centrifuges that could be used at small facilities.

APPENDICES

Appendix A: Summary of results for each test.

Appendix B: MSDS's

- MEK
- IPA
- VM&P Naphtha
- 1044 Press Wash

CENTRIFUGE EXTRACTION OF SOLVENTS ON TOWELS AND WIPERS
IPA (2x)

Towel/Wiper Type	No. of Towels Measured	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Avg. Solvent Removal Efficiency (%)
Launderables	10	22.6	45.2	24.5	1.9	96
SontaraEC	10	7.2	14.4	8.0	0.8	94
Kimtex	10	7.2	14.4	8.3	1.1	92
Workhorse	10	10.4	20.8	12.6	2.2	89

Disposable Cloth Wipers	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Solvent Removal Efficiency (%)	Avg. Solvent Removal Efficiency (%)
Linen	8.5	17.0	9.2	0.7	96	97
Linen	6.6	13.2	6.9	0.3	98	
Towel	19.3	38.6	20.8	1.5	98	97
Towel	19.5	39.0	20.9	1.4	96	
Light Knit	10.5	21.0	11.3	0.8	96	98
Light Knit	9.5	19.0	9.7	0.2	99	
Heavy Knit	12.5	25.0	13.6	1.1	96	95
Heavy Knit	12.1	24.2	13.6	1.5	94	
Flannel	5.9	11.8	6.9	1.0	92	92
Flannel	6.3	12.6	7.3	1.0	92	

Towel/Wiper to Solvent Ratio = 2X
Spin Time: 5 min.
Formulas Used:

2 x (Avg. Towel Wt.) = Est. Initial Solvent Load
(Avg. Solvent & Towel Wt (After Spin)) - (Avg. Towel Wt.) = Avg. Final Solvent Load

(1 - (Avg. Final Solvent Load) / (Est. Initial Solvent Load) x 100) = Solvent Removal Efficiency

CENTRIFUGE EXTRACTION OF SOLVENTS ON TOWELS AND WIPERS
MEK (2x)

Towel/Wiper Type	No. of Towels Measured	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Avg. Solvent Removal Efficiency (%)
Launderables	10	22.9	45.8	23.1	0.2	100
SontaraEC	10	7.2	14.4	7.3	0.1	99
Kimtex	10	7.2	14.4	7.4	0.2	99
Workhorse	10	10.4	20.8	11.2	0.8	96

Disposable Cloth Wipers	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Solvent Removal Efficiency (%)	Avg. Solvent Removal Efficiency (%)
Linen	15.5	31.0	15.3	-0.2	101	101
Linen	15.2	30.4	14.9	-0.3	101	
Towel	22.3	44.6	23.5	1.2	97	97
Towel	21.3	42.6	22.5	1.2	97	
Light Knit	7.5	5.2	7.8	0.3	98	99
Light Knit	5.2	10.4	5.3	0.1	99	
Heavy Knit	13.2	26.4	13.6	0.4	99	100
Heavy Knit	12.7	25.4	12.8	0.1	100	
Flannel	5.8	11.6	5.8	0	100	99
Flannel	5.3	10.6	5.5	0.2	98	

Towel/Wiper to Solvent Ratio = 2X
Spin Time: 5 min.
Formulas Used:

2 x (Avg. Towel Wt.) = Est. Initial Solvent Load

(Avg. Solvent & Towel Wt (After Spin)) - (Avg. Towel Wt.) = Avg. Final Solvent Load
(1 - (Avg. Final Solvent Load) / (Est. Initial Solvent Load) x 100) = Solvent Removal Efficiency

CENTRIFUGE EXTRACTION OF SOLVENTS ON TOWELS AND WIPERS
VM&P Naphtha (2x)

Towel/Wiper Type	No. of Towels Measured	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Avg. Solvent Removal Efficiency (%)
Launderables	10	23.1	46.2	24.8	1.7	96
SontaraEC	10	7.2	14.4	7.4	0.2	99
Kimtex	10	7.2	14.4	8.5	1.3	91
Workhorse	10	10.4	20.8	11.8	1.4	93

Disposable Cloth Wipers	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Solvent Removal Efficiency (%)	Avg. Solvent Removal Efficiency (%)
Linen	12.1	24.2	12.6	0.5	98	99
Linen	17.5	35.0	17.9	0.4	99	
Towel	22.6	45.2	24.1	2.5	95	95
Towel	23.1	46.2	25.8	2.7	94	
Light Knit	11.9	23.8	12.9	1.0	96	96
Light Knit	10.5	21.0	11.4	0.9	96	
Heavy Knit	11.1	22.2	12.0	0.9	96	96
Heavy Knit	12.1	24.2	13.0	0.9	96	
Flannel	6.1	12.2	6.4	0.3	98	98
Flannel	6.4	12.8	6.6	0.2	98	

Towel/Wiper to Solvent Ratio = 2X
Spin Time: 5 min.
Formulas Used:

2 x (Avg. Towel Wt.) = Est. Initial Solvent Load

(Avg. Solvent & Towel Wt (After Spin)) - (Avg. Towel Wt.) = Avg. Final Solvent Load
(1 - (Avg. Final Solvent Load) / (Est. Initial Solvent Load) x 100) = Solvent Removal Efficiency

CENTRIFUGE EXTRACTION OF SOLVENTS ON TOWELS AND WIPERS
Used 1044 Press Wash (2x)

Towel/Wiper Type	No. of Towels Measured	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Avg. Solvent Removal Efficiency (%)
Launderables	10	22.1	44.2	24.9	2.8	94
SontaraEC	10	7.2	14.4	8.2	1.0	93
Kimtex	10	7.2	14.4	9.1	1.9	87
Workhorse	10	10.4	20.8	13.3	2.9	86

Disposable Cloth Wiper	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Solvent Removal Efficiency (%)	Avg. Solvent Removal Efficiency (%)
Linen	12.3	24.6	14.9	2.6	89	91
Linen	16.0	32.0	18.1	2.1	93	
Towel	20.4	40.8	23.9	3.5	91	91
Towel	20.4	40.8	23.9	3.5	91	
Light Knit	7.8	15.6	9.1	2.7	83	84
Light Knit	7.7	15.4	9.2	2.5	84	
Heavy Knit	22.4	44.8	29.5	7.5	84	85
Heavy Knit	24.1	48.2	31.1	7.0	86	
Flannel	5.5	11.0	6.5	1.0	91	91
Flannel	5.5	11.0	6.4	1.1	90	

Towel/Wiper to Solvent Ratio = 2X
Spin Time: 5 min.
Formulas Used:

2 x (Avg. Towel Wt.) = Est. Initial Solvent Load

(Avg. Solvent & Towel Wt (After Spin)) - (Avg. Towel Wt.) = Avg. Final Solvent Load
(1 - (Avg. Final Solvent Load) / (Est. Initial Solvent Load) x 100) = Solvent Removal Efficiency

CENTRIFUGE EXTRACTION OF SOLVENTS ON TOWELS AND WIPERS
1044 Press Wash (2x)

Towel/Wiper Type	No. of Towels Measured	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Avg. Solvent Removal Efficiency (%)
Launderables	10	22.8	45.6	25.2	2.4	95
SontaraEC	10	7.2	14.4	8.2	1.0	93
Kimtex	10	7.2	14.4	9.1	1.9	87
Workhorse	10	10.4	20.8	12.8	2.4	89

Disposable Cloth Wiper	Avg. Towel Wt. (g)	Est. Initial Solvent Load (g)	Avg. Solvent & Towel Wt. (After Spin) (g)	Avg. Final Solvent Load (g)	Solvent Removal Efficiency (%)	Avg. Solvent Removal Efficiency (%)
Linen	12.1	24.2	13.4	1.3	95	94
Linen	12.1	24.2	13.7	1.6	93	
Towel	19.7	39.4	22.0	2.3	94	95
Towel	19.7	39.4	21.7	2.0	95	
Light Knit	7.0	14.0	8.3	1.3	91	92
Light Knit	7.9	15.8	9.0	1.1	93	
Heavy Knit	11.1	22.2	12.6	1.5	93	94
Heavy Knit	15.6	31.2	17.2	1.6	95	
Flannel	13.0	26.0	14.7	1.7	94	93
Flannel	5.5	11.0	6.5	1.0	91	

Towel/Wiper to Solvent Ratio = 2X
Spin Time: 5 min.
Formulas Used:

2 x (Avg. Towel Wt.) = Est. Initial Solvent Load

(Avg. Solvent & Towel Wt (After Spin)) - (Avg. Towel Wt.) = Avg. Final Solvent Load
(1 - (Avg. Final Solvent Load) / (Est. Initial Solvent Load) x 100) = Solvent Removal Efficiency

CENTRIFUGE EXTRACTION OF SOLVENTS ON TOWELS AND WIPERS
1044 Press Wash (0.5x)

Towel/Wiper Type	No. of Towels Measured	Total Towel Wt. (g)	Initial Solvent Load (Total Wt. in g)	Total Solvent & Towel Wt. (After Spin) (g)	Final Solvent Load (Total Wt. in g)	Avg. Solvent Removal Efficiency (%)
Launderables	20	390	195	425	35	82
SontaraEC	10	72.9	36.0	80.4	7.5	79
Kimtex	10	73.3	36.7	83.1	9.8	73
Workhorse	10	105.7	52.9	123.5	17.8	66

Disposable Cloth Wiper	Individual Towel Wt. (g)	Initial Solvent Load (g)	Total Solvent & Towel Wt. (After Spin) (g)	Final Solvent Load (g)	Solvent Removal Efficiency (%)	Avg. Solvent Removal Efficiency (%)
Linen	6.3	3.2	7.1	0.8	75	73
Linen	6.3	3.2	7.2	0.9	72	
Towel	22.1	11.1	24.7	2.6	77	77
Towel	25.4	12.7	28.5	3.1	76	
Light Knit	8.3	4.2	9.3	1.0	76	73
Light Knit	7.9	4.0	9.1	1.2	70	
Heavy Knit	9.8	4.9	10.5	0.7	86	89
Heavy Knit	11.5	5.8	12.0	0.5	91	
Flannel	5.2	2.6	6.1	0.9	65	68
Flannel	5.3	2.7	6.1	0.8	70	

Towel/Wiper to Solvent Ratio = 0.5X
Spin Time: 5 min.
Formulas Used:

0.05 x (Towel Wt.) = Initial Solvent Load

(Total Solvent & Towel Wt (After Spin)) - (Total Towel Wt.) = Final Solvent Load (Note: Individual towel weight used for disp. cloth wipers.)

(1 - (Final Solvent Load) / (Initial Solvent Load) x 100) = Solvent Removal Efficiency

CENTRIFUGE EXTRACTION OF SOLVENTS ON TOWELS AND WIPERS
1044 Press Wash (Saturated)

Towel/Wiper Type	No. of Towels Measured	Total Towel Wt. (g)	Total Towel & Solvent Wt. (g)	Initial Solvent Load (g)	Total Solvent & Towel Wt. (After Spin) (g)	Final Solvent Load (g)	Avg. Solvent Removal Efficiency (%)
Launderables	20	385	1280	895	430	45	95
SontaraEC	10	71.8	280	208	82.1	10.3	95
Kimtex	10	72.5	345	273	90.5	18.0	93
Workhorse	10	105.3	370	265	128.5	23.2	91

Disposable Cloth Wiper	Individual Towel Wt. (g)	Total Towel & Solvent Wt. (g)	Initial Solvent Load (g)	Total Solvent & Towel Wt. (After Spin) (g)	Final Solvent Load (g)	Solvent Removal Efficiency (%)	Avg. Solvent Removal Efficiency (%)
Linen	10.8	27.2	16.4	11.8	1.0	94	94
Linen	10.5	25.2	14.7	11.4	0.9	94	
Towel	21.3	70.1	48.8	23.8	2.5	95	95
Towel	20.7	67.8	47.1	23.1	2.4	95	
Light Knit	10.5	29.9	19.4	12.3	1.8	91	92
Light Knit	11.4	32.6	21.2	13.0	1.6	93	
Heavy Knit	10.5	30.3	19.8	11.2	0.7	96	97
Heavy Knit	9.8	27.8	18.0	10.2	0.4	98	
Flannel	5.6	22.2	16.6	6.3	0.7	96	96
Flannel	5.2	21.0	15.8	5.9	0.7	96	

Towel/Wiper to Solvent Ratio =Saturated
Spin Time: 5 min.
Formulas Used:

(Total Towel & Solvent Wt.) - (Total Towel Wt.) = Initial Solvent Load (Note: Individual towel weight used for disp. cloth wipers.)

(Total Solvent & Towel Wt (After Spin)) - (Towel Towel Wt.) = Final Solvent Load (Note: Individual towel weight used for disp. cloth wipers.)

(1 - (Final Solvent Load) / (Initial Solvent Load) x 100) = Solvent Removal Efficiency